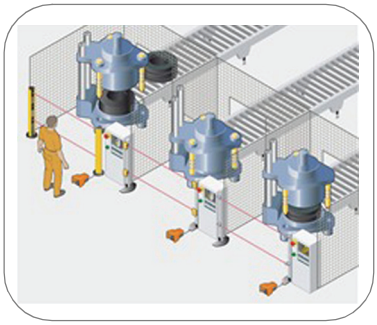
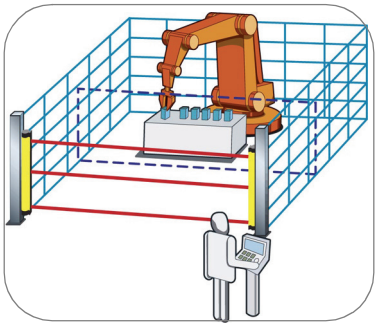
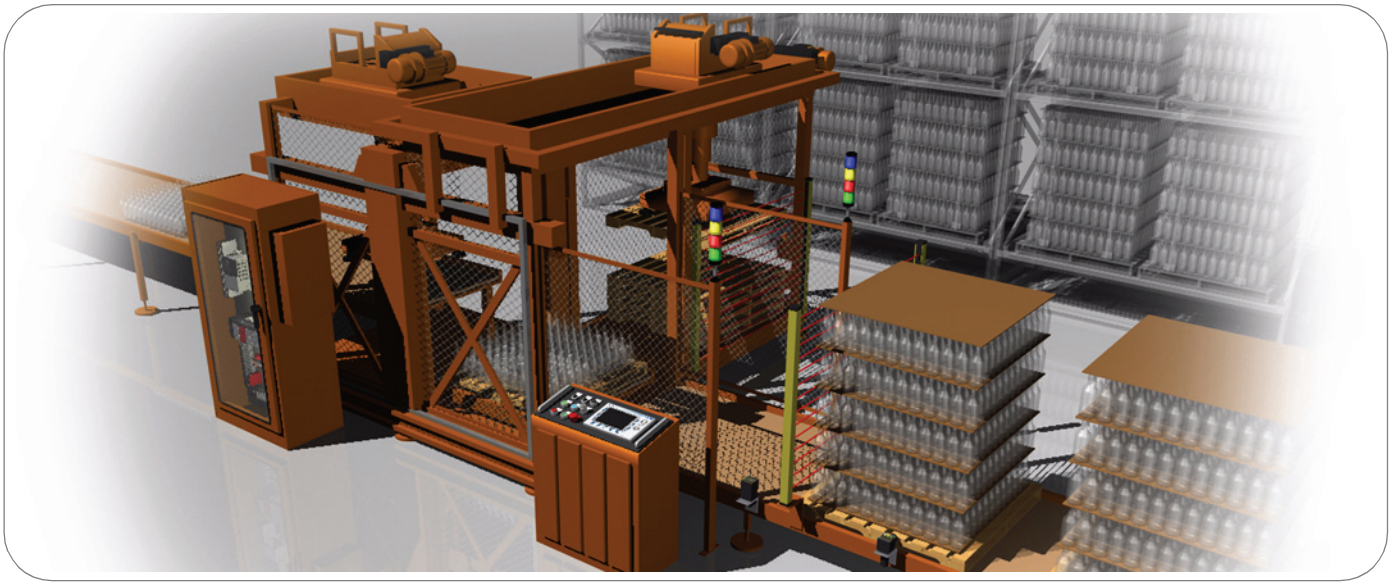
Area Access Control Safety Single Beam User Manual

Allen-Bradley

Guardmaster®







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Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in the guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Rockwell Automation publication SGI-1.1, Safety Guidelines for the Application, Installation and Maintenance of Solid-State Control (available from your local Rockwell Automation sales office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

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Throughout this manual we use notes to make you aware of safety considerations:

WARNING	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.
ATTENTION	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequences.
SHOCK HAZARD	Labels may be on or inside the equipment (for example, drive or motor) to alert people that dangerous voltage may be present.
BURN HAZARD	Labels may be on or inside the equipment (for example, drive or motor) to alert people that surfaces may reach dangerous temperatures.

It is recommended that you save this user manual for future use.

Conditions required for proper use of the AAC Safety Single-Beam Light Curtain

The AAC safety single beams are intended to provide area access control or perimeter safeguarding of personnel for a variety of machinery and work cell applications.

Please make sure that you read and understand the following requirements before locating and installing the AAC safety single beam.

The installation of the AAC safety single beam must comply with all applicable federal, state, and local rules, regulations, and codes.

AAC safety single beam must be properly installed by qualified personnel.

AAC safety single beams are presence sensing devices and will not protect personnel from heat, chemicals, or flying parts. They are intended to signal a stop of hazardous machine motion when the sensing field is broken.

AAC safety single beams can only be used on machinery which can be stopped anywhere in the machinery's stroke or cycle.

AAC safety single beam should never be used on full revolution clutched machinery.

The effectiveness of the AAC safety single beam depends upon the integrity of the machine control circuit. The machinery that the AAC safety single beam presence sensing device is installed on, should have control circuitry that is fail safe in design.

All stopping mechanisms for the machinery should be inspected regularly to ensure proper operation. The protected machinery must have a consistent reliable and repeatable stopping time.

It is the responsibility of the employer to properly install, operate and maintain the product as well as the machinery on which the AAC safety single beam presence sensing device is installed.

ATTENTION Failure to read and follow these instructions can lead to misapplication or misuse of the AAC safety single beam, resulting in personal injury and damage to equipment.

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About this document

Please read this chapter carefully before you work with these operating instructions and the Area Access Control (AAC) single-beam photoelectric safety switches, referred to in the following as AAC devices.

IMPORTANT	This user manual is part of the light curtain product and therefore must be kept accessible during the whole life cycle for everyone who is in charge of installation, operation, maintenance, and safety control.

Function of this document

These operating instructions are designed to address the technical personnel of the machine manufacturer or the machine operator in regards to safe mounting, installation, configuration, electrical installation, commissioning, operation and maintenance of the AAC devices.

These operating instructions do not provide instructions for operating machines on which the AAC devices are, or will be, integrated. Information on this is to be found in the appropriate operating instructions for the machine.

Target group

These operating instructions are addressed to planning engineers, machine designers and operators of plants and systems which are to be protected by the AAC devices. They are also addressed to people who integrate the AAC devices into a machine, initialise its use, or who are in charge of servicing and maintaining the device.

Scope

These operating instructions are only applicable to the AAC single-beam photoelectric safety switch.

Depth of information

These operating instructions contain the following information on the AAC devices:

- Mounting
- Electrical installation
- Commissioning
- Application
- Error diagnosis and troubleshooting
- Part numbers
- Conformity and approval
- Care and maintenance

Planning and using protective devices such as the AAC devices also require specific technical skills which are not detailed in this documentation.

When operating the AAC devices, the national, local and statutory rules and regulations must be observed.

Additional reference information is available on the Rockwell Automation website at www.rockwellautomation.com or www.ab.com/safety.

On the Rockwell Automation website you will find information regarding:

- Sample applications,
- These operating instructions in different languages for viewing and printing,
- EC declaration of conformity and other documents.

Abbreviations

AAC Area Access Control

EDM External device monitoring

ESD Electro-static discharge

ESPE Electro-sensitive protective equipment

LED Light Emitting Diode

OSSD Output signal switching device

Terminology, symbols used

Recommendations

Recommendations are designed to give you some assistance in your decision-making process with respect to a certain function or a technical measure.

Note: Refer to notes for special features of the device.

LED symbols describe the state of a diagnostics LED. Examples:

●	**Red**	The red LED is illuminated constantly.
☀	**Yellow**	The yellow LED is flashing.
○	**Green**	The green LED is off.

➢ Take action...
Instructions for taking action are shown by an arrow. Read carefully and follow the instructions for action.

ATTENTION	Potentially hazardous situation, which, if not prevented, might lead to serious or deadly injury. Failure to observe may result in dangerous operation.

Transmitter and Receiver

In drawings and diagrams, the symbol denotes the transmitter and the symbol denotes the receiver.

The term “dangerous state”

The dangerous state (standard term) of the machine is always shown in the drawings and diagrams of this document as a movement of a machine part. In practical operation, there may be a number of different dangerous states:

- Machine movements,
- Electrical conductors,
- Visible or invisible radiation,
- A combination of several risks and hazards.

On safety

This chapter deals with your own safety and the safety of the equipment operators.

➢ Please read this chapter carefully before working with the AAC devices or with the machine protected by the AAC devices.

Qualified safety personnel

The AAC devices must be mounted, commissioned and serviced only by qualified safety personnel. Qualified safety personnel are defined as persons who:

- Have undergone the appropriate technical training

and

- Have been instructed by the responsible machine operator in the operation of the machine and the current valid safety guidelines.

and

- Have access to these operating instructions.

Applications of the device

The AAC devices are electro-sensitive protective equipment (ESPE), type 4 in accordance with IEC 61496-1 and IEC 61496-2 and may for this reason be used in controllers of safety category 4 in accordance with EN ISO 13849-1, SIL CL3 in accordance with EN 62061 or up to PL e in accordance with EN ISO 13849-1. The AAC devices are used for:

- Hazardous area protection,
- Access protection.

The photoelectric safety switch must be installed such that the hazardous area can only be reached by interrupting the light path between sender and receiver. It must not be possible to start the machine/system as long as personnel are within the hazardous area.

The AAC devices are intended only for use in industrial environments. When used in residential areas it can cause radio interferences.

Please refer to “Application example” on page 7 for an illustration of the protection mode and an example application.

ATTENTION	Only use the AAC devices as an indirect protective measure! Opto-electronic protective devices as the AAC devices cannot provide any protection against parts thrown out or against radiation. Transparent objects are not detected.

Depending on the application, mechanical protective devices may be required in addition to the AAC devices.

Correct use

The AAC devices may only be used as specified in “Applications of the device” on page 5. They are only allowed to be used by qualified safety personnel and only on the machine on which they have been installed and initialized by qualified safety personnel as per these operating instructions.

All warranty claims against Rockwell Automation are forfeited in the case of any other use, or alterations being made to the AAC devices, even as part of their mounting or installation.

General safety notes and protective measures

IMPORTANT	Please observe the following items in order to ensure the correct and safe use of the AAC devices.

- National/international rules and regulations apply to the installation, commissioning, use and periodic technical inspections of the AAC devices, in particular:
  - → The Machinery Directive 2006/42/EC,
  - → Provision and Use of Work Equipment Directive 89/655/EC,
  - → The work safety regulations/safety rules,
  - → Other relevant safety regulations.
- Manufacturers and operators of the machine on which the AAC devices are used are responsible for obtaining and observing all applicable safety regulations and rules.
- It is imperative the test notes from page 16 of these operating instructions (“Tests before the first commissioning,” “Daily functional checks of the protective device,” “Regular inspection of the protective device by qualified safety personnel”) are followed.

- The tests must be carried out by qualified safety personnel or specially qualified and authorised personnel and must be recorded and documented to ensure that the tests can be reconstructed and retraced at any time.
- The operating instructions must be made available to the operator of the machine where the AAC devices are used. The machine operator is to be instructed in the use of the device by qualified safety personnel and must be instructed to read the operating instructions.
- The external voltage supply for the devices must be capable of buffering brief mains voltage failures of 20 ms as specified in EN 60204. Suitable power supplies are available from Rockwell Automation.
- A safety extra-low voltage SELV/PELV must be used to supply power to the AAC devices.

Environmental protection

The AAC devices are constructed in such a way that they adversely affect the environment as little as possible. The devices use only a minimum of power and natural resources.

At work, always act in an environmentally responsible manner. For this reason please note the following information on disposal.

Disposal

➢ Always dispose of unserviceable or irreparable devices in compliance with local/national rules and regulations with respect to waste disposal.

Information on the individual materials in the AAC is given in “Technical specifications” on page 19.

Product description

This chapter provides information on the special features, the operating principle, the structure and the function of the AAC devices.

Please read this chapter before mounting, installing and commissioning the AAC devices.

Special features

- Relay outputs
- Rugged type of construction
- Long operating range up to 70 m
- Heated front window

Operating principle of the device

The AAC single-beam photoelectric safety switch consists of a transmitter unit and a receiver. The transmitter unit emits a beam of light that is received by the receiver unit.

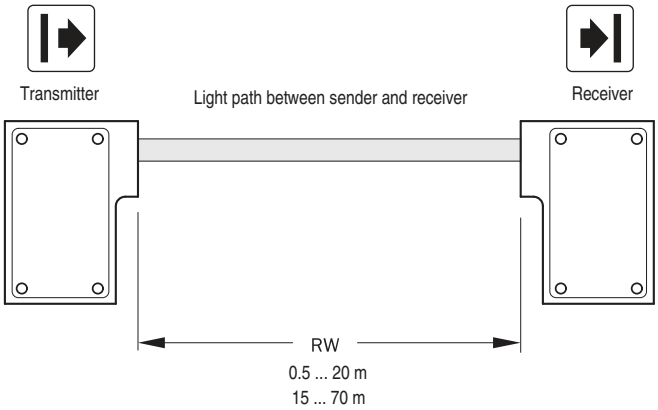

Figure 1: Key data for the AAC devices

If the light beam is interrupted by an object, a switching command is triggered. The machine controller that evaluates this message must then bring the dangerous movement to a halt.

Transmitter and receiver units are equipped with LEDs for the operational check. Their function as diagnostic elements is described in “Commissioning” on page 15.

The diagnostics LEDs are used for fault diagnosis (see “Fault diagnosis” on page 17).

The AAC devices are not equipped with an internal restart interlock.

Scanning range

ATTENTION	Use the receiver with the permitted operating range to suit the length of the light path between the sender and receiver! • If operating range is too low, the AAC single-beam photoelectric safety switch may not switch to green. • If the operating range is too large, the AAC single-beam photoelectric safety switch may malfunction due to reflections. This would mean that the operator is at risk.

Two receivers with different scanning ranges are available:

Receiver	Operating range
440L-R4F0020Q	0.5...20 m
440L-R4F1570Q	15...70 m

Table 2: Receiver variants

Restart interlock

The AAC devices do not have an internal restart interlock. It is only possible to implement a restart interlock for the machine externally. During this process the AAC devices have no control over the restart.

Note: A restart interlock prevents the machine starting again after an error or an interruption of the light path.

ATTENTION	Always operate the application with restart interlock! Ensure an external restart interlock is always activated on the machine. The AAC devices are unable to verify if the external restart interlock of the machine is operable. If you deactivate the external restart interlock, the operator of the machine will be at risk of injury.

External device monitoring (EDM)

The AAC devices do not have any feature for monitoring the downstream contactors. External device monitoring on the downstream contactors is only possible with an external circuit. You will find additional explanations on the connection of downstream contactors in “System connection” on page 13.

Note: An EDM checks if the downstream contactors actually de-energize when the protective device is tripped.

Front Window Heating

Transmitter and receiver have heated front windows. The front window heating counteracts the formation of droplets, mist, frost and ice.

ATTENTION	Ensure the optical properties of the front window are not changed by the formation of droplets, mist, frost or ice, otherwise there will be a hazard for the operator.

Structure and function

The AAC devices are equipped with diagnostics LEDs:

Diagnostics LEDs of the transmitter

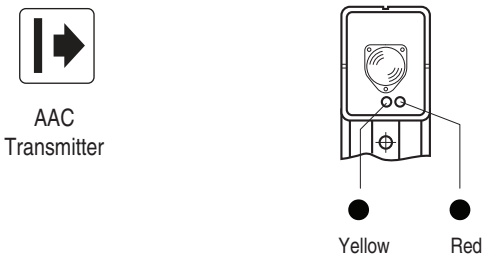

Figure 2: Diagnostics LEDs

Display		Meaning
Yellow	Red	
●	○	Device on, test inactive
●	●	Device on, test active, test contacts open

Table 3: Diagnostics LEDs

Diagnostics LEDs of the receiver

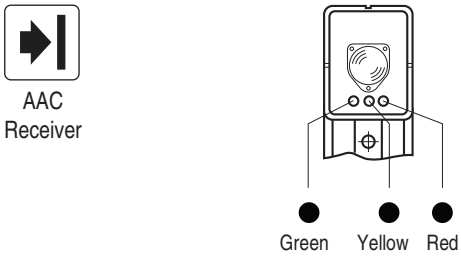

Figure 3: Diagnostics LEDs

Display			Meaning
Green	Yellow	Red	
●	○	○	Output signal switching devices on, light path unoccupied
○	○	●	Output signal switching devices off, light path interrupted or inadequate alignment or device not yet ready after switch on (see “Technical specifications” on page 19)
●	●	○	Output signal switching devices on, light path unoccupied, weak signal
○	●	●	Output signal switching devices off, light path interrupted or inadequate alignment. Prior to the complete interruption of the light path the signal was weak.

Table 4: Diagnostics LEDs

Application example

The AAC devices are used as access protection for hazardous areas on machines or systems (Figure 4). The devices are permanently mounted in the access area with the necessary safety distance from the nearest hazardous point. If the light beam is interrupted by an object, a switching command is triggered. The machine controller that evaluates this message must then bring the dangerous movement to a halt.

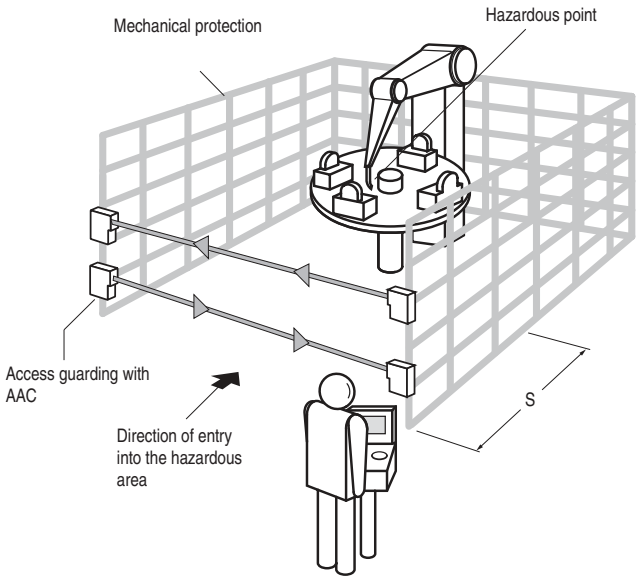

Figure 4: Access guarding with AAC

Mounting

This chapter describes the preparation and completion of the installation of the AAC devices:

- Calculating the necessary safety distance,
- Calculating the distance from reflective surfaces,
- Mounting the device.

The following steps are necessary after mounting:

- Complete the electrical connections (page 12),
- Alignment of transmitter and receivers (page 15),
- Testing the installation (page 16).

ATTENTION	No protective function without properly calculated safety distance. The reliable protective effect of the AAC single-beam photoelectric safety switches depends on the AAC devices being mounted with the correct safety distance from the hazardous point.

Preparation for mounting

Safety distance for access protection

A safety distance must be maintained between the protective field and the hazardous point. This safety distance ensures that the hazardous point can only be reached after the dangerous state of the machine has been completely stopped.

The safety distance as per EN 999+A1❶ and EN ISO 13857 depends on:

- Stopping/run-down time of the machine or system (The stopping/run-down time is shown in the machine documentation or must be determined by taking a measurement.),
- Response time of the entire protective device,
- Reach or approach speed,
- Number of beams/beam separation.

Under the authority of OSHA and ANSI the safety distance as specified by ANSI B11.19 (Annex D) E.4.2.3.3.5 and Code of Federal Regulations, Volume 29, Part 1910.217...(h) (9) (v) depends on:

- Stopping/run-down time of the machine or system (The stopping/run-down time is shown in the machine documentation or must be determined by taking a measurement.),
- Response time of the entire protective device,
- Reach or approach speed,
- Other parameters that are stipulated by the standard depending on the application.

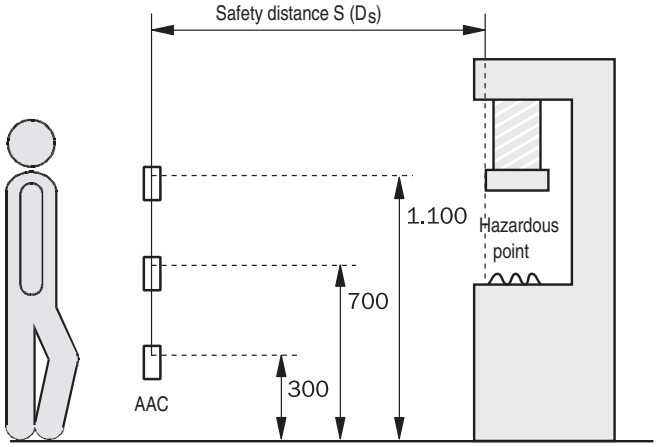

Figure 5: Safety distance S to the light beam

How to calculate the safety distance S according to EN 999+A1❶ and EN ISO 13857:

Note: The following calculation shows an example calculation of the safety distance. Depending on the application and the ambient conditions, a different calculation may be necessary.

➢ First, calculate S using the following formula:

❶ In the future EN ISO 13855.

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$S = K \times T + C$ [mm]

Where…

T = Stopping/run-down time of the machine + response time of the AAC devices after light path interruption [s]

S = Safety distance [mm]

K = Approach speed 1.6 [m/s]

C = Depending on the number of beams (1, 2, 3 or 4), see Table 5.

Number of beams	1	2	3	4
Height of the beams above the floor [mm]	750	400 900	300 700 1,100	300 600 900 1,200
C	1,200	850	850	850

Table 5: Height of the beams above the floor

Example:

Access guarding with two beams C = 850 mm
Stopping/run-down time of the machine = 290 ms
Response time after light path interruption = 22 ms
Approach speed = 1.6 m/s

T = 290 ms + 22 ms = 312 ms = 0.31 s
S = 1,600 × 0.31 + 850 = 1,346 mm

How to calculate the safety distance D_S according to ANSI B11.19 (Annex D) E.4.2.3.3.5 and Code of Federal Regulations, Volume 29, Part 1910.217 … (h) (9) (v):

Note: The following calculation shows an example calculation of the safety distance. Depending on the application and the ambient conditions, a different calculation may be necessary.

First, calculate D_S using the following formula:

$$D_S = H_S \times (T_S + T_C + T_r + T_{bm}) + D_{pf}$$

Where…

D_S = The minimum distance in inches (or millimeters) from the hazardous point to the protective device

H_S = A parameter in inches/second or millimeters/second, derived from data on approach speeds of the body or parts of the body. Often 63 inches/second is used for H_S.

T_S = Stopping/run down time of the machine tool measured at the final control element

T_C = Stopping/run-down time of the control system

T_r = Response time of the entire protective device after light path interruption

T_{bm} = Additional response time allowed for brake monitor to compensate for wear

Note: Any additional response times must be accounted for in this calculation.

D_{pf} = An additional distance added to the overall safety distance required. This value is based on intrusion toward the hazardous point prior to actuation of the electro-sensitive protective equipment (ESPE). For applications that can be reached over, the value D_{pf} = 1.2 m. For beam arrangements that permit reaching in with the arms or the detectable object size is greater than 63 mm, the value D_{pf} = 0.9 m.

ATTENTION

Maintain the safety distance!

The AAC devices are to be installed such that when the light beam is interrupted, the hazardous point is only reached when the dangerous state is no longer present.

ATTENTION

Risk of failure to detect!

Persons who are in the hazardous area but not in the light path between sender and receiver are not detected by the AAC devices. It is therefore necessary to ensure that the hazardous area is fully visible and any dangerous state can only be initiated if there are no personnel in the hazardous area.

The AAC devices are not allowed to be used for hand and finger protection.

The applicable legal and official regulations apply to the use and mounting of the protective device. These regulations vary depending on the application.

Minimum distance to reflective surfaces

The light beams from the sender may be deflected by reflective surfaces. This can result in failure to identify the object.

Therefore all reflective surfaces and objects (e.g. material bins) must be a minimum distance a from the light path between sender and receiver of the AAC devices. The minimum distance a depends on the distance D between sender and receiver.

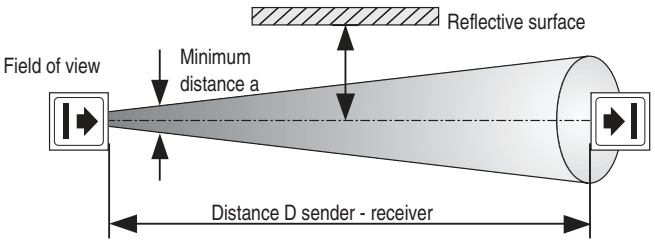


Figure 6: Minimum distance to reflective surfaces

Note: Transmitter and receiver optics have the same field of view.

ATTENTION

The minimum distances to reflective surfaces only apply when the sensing field is not interrupted.

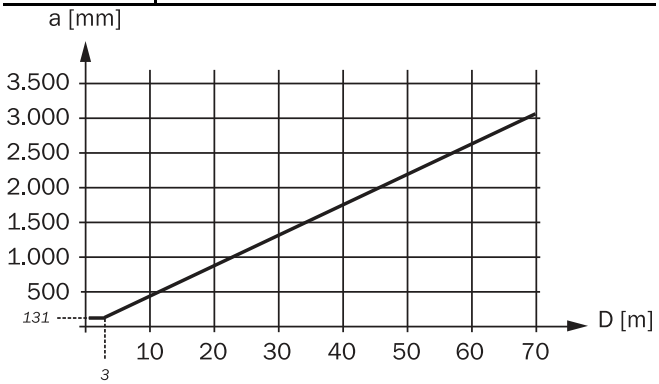


Figure 7: Graph, minimum distance from reflective surfaces

Distance D [m] sender – receiver	Calculation of the minimum distance a from reflective surfaces
D ≤ 3 m	a [mm] = 131
D > 3 m	a [mm] = tan (2.5°) x 1,000 x D [m] = 43.66 x D [m]

Table 6: Formula for the calculation of the minimum distance to reflective surfaces

Mutual interference of systems in close proximity

ATTENTION

Prevent the mutual interference of systems mounted in close proximity!

If several AAC devices operate in close physical proximity, the transmitted beams from one device may interfere with the receiver for another device such that the protective function of the different AAC devices is no longer ensured and there is a hazard for the operator. You must avoid such mounting scenarios or take appropriate measures, e.g. by mounting non-reflective sight protection walls or by reversing the transmission direction of a device.

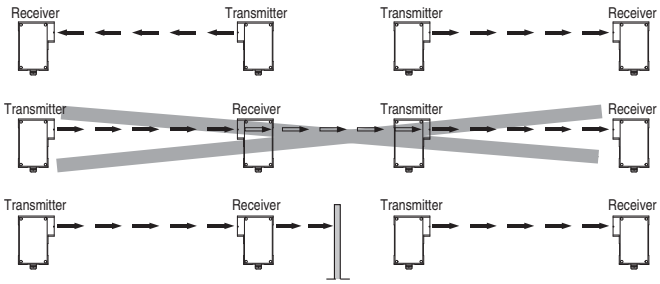


Figure 8: Mounting two AAC devices in series

Mechanical mounting

The AAC transmitter and receiver are to be mounted to suit the local conditions on one of the sides of their housing or using the mounting bracket. The mounting bracket significantly eases alignment. The device can be operated in any position. The AAC transmitter and receivers are, however, to be mounted such that the axis of the beam emitted by the transmitter is always aligned with the axis of the receiver optics (alignment sight, see Figure 18 on page 16).

Note: The mounting brackets are to be attached such that all screws are easily accessibly for alignment. The devices are to be attached such that it is possible to align with the related device opposite using the alignment sight.

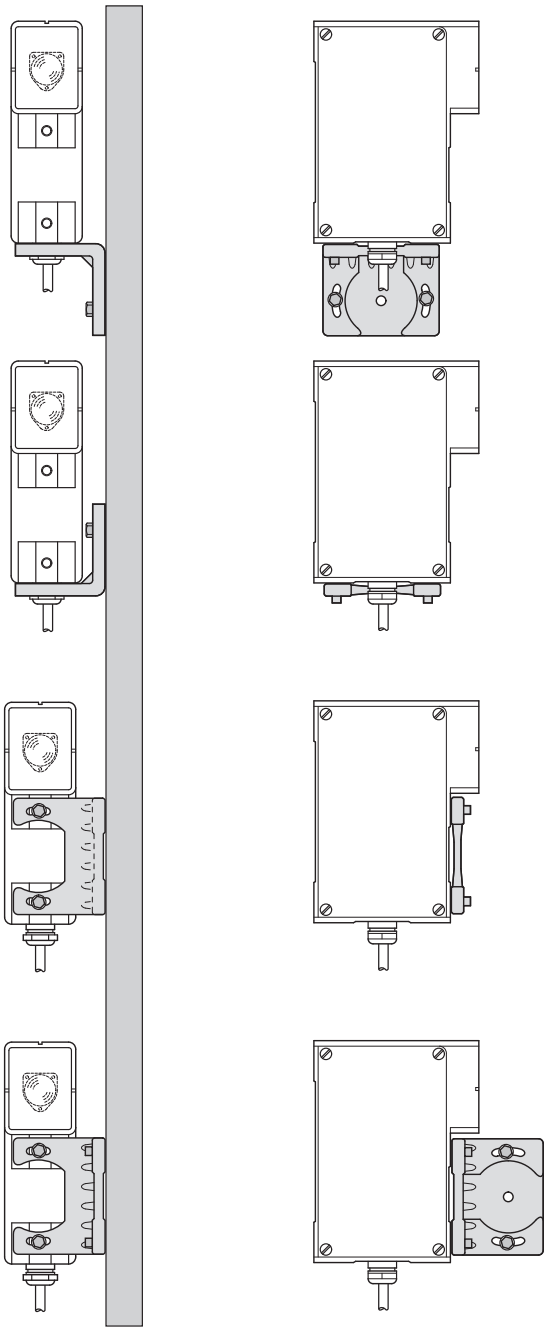


Figure 9: Mounting possibilities using mounting brackets

Corner mirror

With the AAC and corner mirrors, access protection on several sides can be realized (Figure 10 on page 11).

Note: The usage of corner mirrors reduces the effective scanning range of the system AAC as specified in Table 7 on page 11.

Note: The usage of mirrors (Figure 11 on page 12) requires very precise alignment. It is recommended to use the laser alignment aid. The alignment aid is available as an accessory (Table 16 on page 21).

Number of mirrors	AAC with short scanning range	AAC with long scanning range
1	0.5...18 m	14.2...63 m
2	0.5...16 m	13.5...56 m
3	0.5...14.3 m	12.8...50 m
4	0.5...12.8 m	12.2...45 m

Table 7: Reduction in the scanning range on the usage of corner mirrors with $\alpha = 90°$

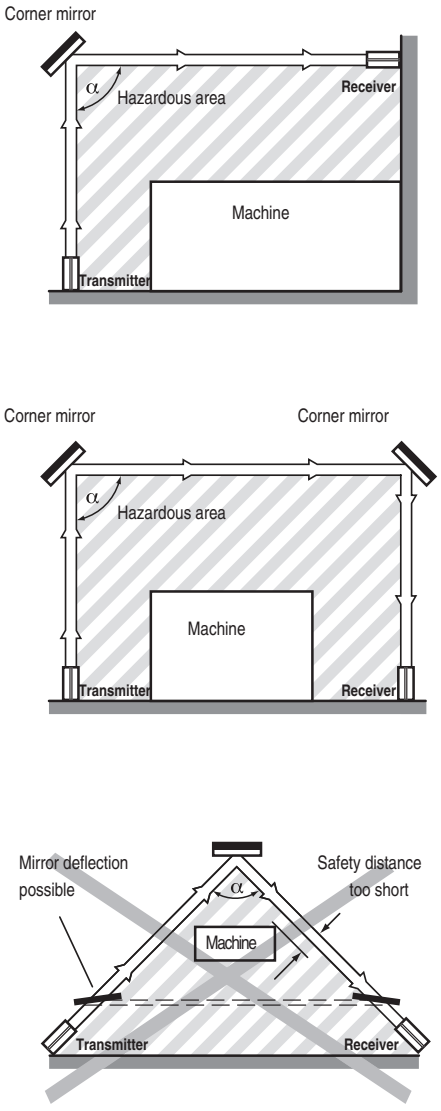


Figure 10: Hazardous area protected on several sides

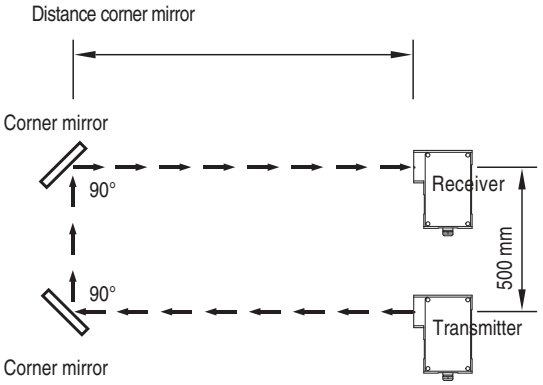


Figure 11: Two-beam protection with one system AAC

AAC receiver	Distance corner mirror – AAC
Low scanning range	0.5...7.5 m
High scanning range	> 7.5 m

Table 8: Distances of the corner mirrors

Note: If there are reflective surfaces in the area of the light path between the transmitter and receiver or such surfaces may occur, the alignment of the system must be adjusted:
Transmitter and receiver must always be aligned such that there are no reflecting surfaces in the area of the field of view (see Figure 13 on page 12).

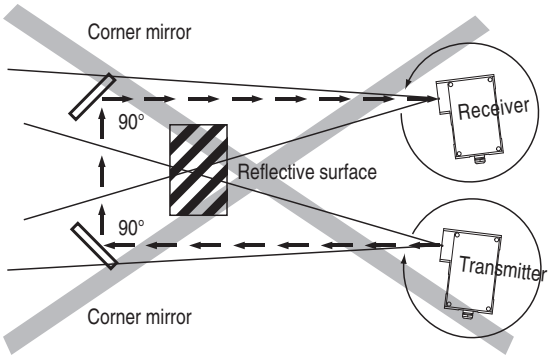


Figure 12: Incorrect alignment of transmitter and receiver

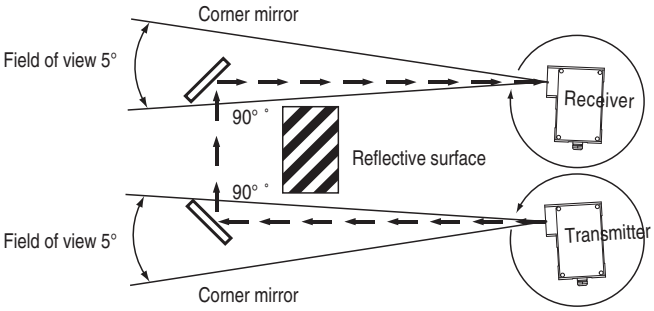


Figure 13: Correct alignment of transmitter and receiver

Electrical installation

Important information for the installation

ATTENTION

Switch the entire machine/system off line before installation.

The machine/system could inadvertently start up while you are connecting the devices. Ensure that the entire machine/system is disconnected during the electrical installation.

Note:

- The AAC single-beam photoelectric safety switch meets the interference suppression requirements (EMC) for industrial use (interference suppression class A). When used in residential areas it can cause interference.
- A safety extra-low voltage SELV/PELV must be used to supply power to the AAC devices.
- The external voltage supply must bridge a brief mains failure of 20 ms (EN 60204). Suitable power supplies are available as accessories from Rockwell Automation.
- Prior to opening the cover (see “Dimensional drawings” on page 22) all cables for the supply voltage and the relay connections must be electrically isolated.
- Only open the device with appropriate protection against ESD, i.e. pay attention to grounding. In the device, only touch the connection terminals, not the other parts of the electronics. All work on the open device is only allowed to be undertaken by qualified safety personnel.
- If the cover is open, the device does not provide any protective function.
- The connecting cables must be laid directly to the terminal strip.
- After mounting, the firm seating of the connecting cables in the connection terminals must be checked.
- Observe torque figure for the protective conductor connection (“PE”) (see “System connection” on page 13).
- On the installation of another PG connector, it is necessary to comply with the torque data for the PG connector (see “Dimensional drawings” on page 22).
- Prior to screwing the cover in place, the seal must be checked for contamination and damage. Fasten the cover to the related torque (see “Dimensional drawings” on page 22).
- After opening the cover, the complete commissioning function test must be performed (see “Commissioning” on page 15).

System connection

Pin assignment transmitter

Pin	Designation
1/2	Voltage supply 24 V DC
3	Ground 0 V
10	Test contacts
11	
PE	Protective earth

Table 9: Assignment of the sensor contacts, AAC transmitter

Note: The torque for the PE connection is 2.0 ± 0.5 Nm.

Note: Connect the contacts on the AAC only to circuits that comply with the requirements for safety extra-low voltage (SELV/PELV).

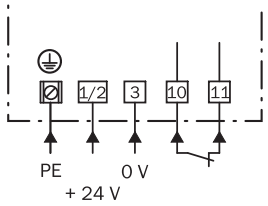


Figure 14: Assignment of the sensor contacts, transmitter

The test makes it possible to check the loads connected. For this purpose the electrical connection between test contacts 10 and 11 on the AAC is interrupted for a certain amount of time (see “Technical specifications” on page 19). As a result the transmitter does not emit a beam of light and simulates an interruption to the light path.

The test must be performed by the machine controller during the nonhazardous phase (e.g. an nonhazardous movement). If the test is not successful, the machine must receive a shut down signal from the machine controller.

Note: To operate the AAC devices without testing, a wire jumper must be connected between the test contacts 10 and 11 on the AAC.

ATTENTION	Use test function for the purpose described! The test input is only allowed to be used in the manner described.

Pin assignment receiver

Pin	Designation
1/2	Voltage supply 24 V DC
3	Ground 0 V
4	Safety relay, normally open contact
5	
6	Safety relay 1/2, normally closed contacts connected in parallel internally
7	
8	Safety relay 2, normally open contact
9	
PE	Protective earth

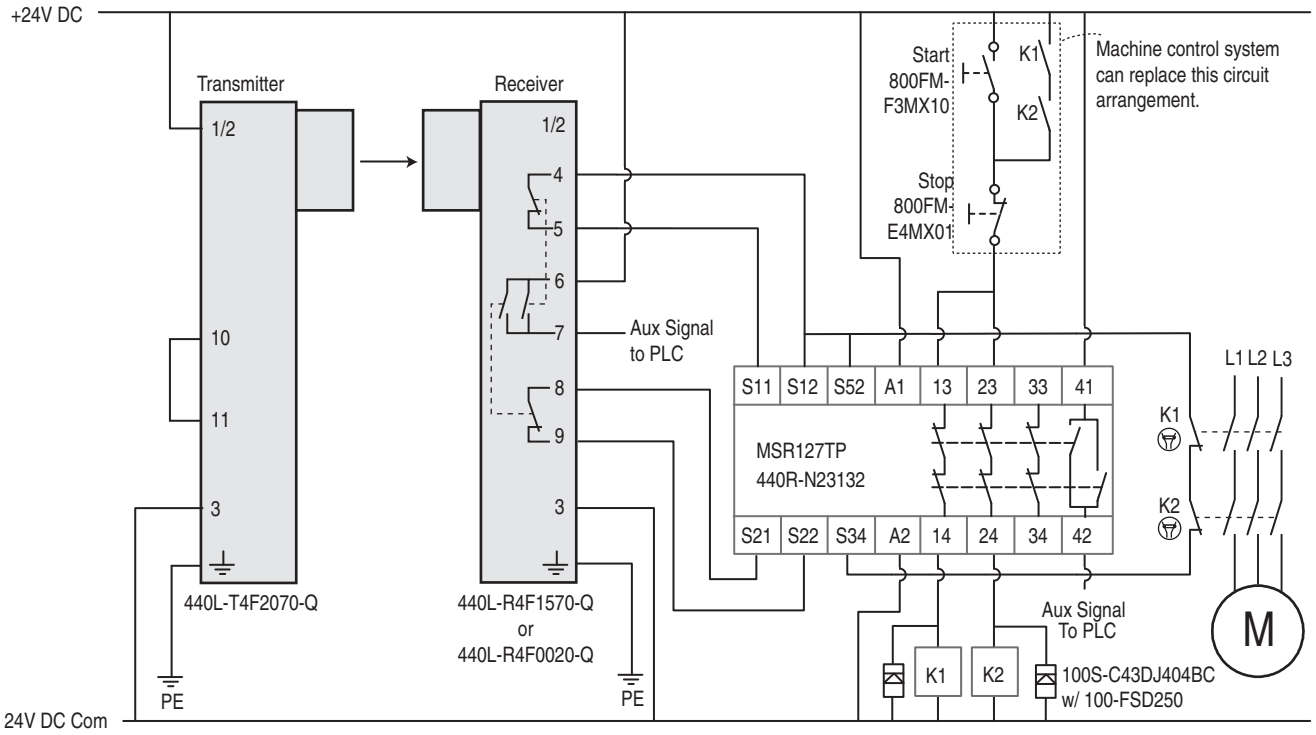
Table 10: Assignment of the sensor contacts, receiver

Both normally open contacts are to be used for safety-related functions. In a subsequent dual-channel circuit the two normally open outputs are to be connected to a safety controller with a suitable level of safety (see Figure 15).

The normally closed contacts are not allowed to be used for safety-related functions.

If the downstream logic is realized using discrete contactors, they must be positively guided and externally monitored. The monitoring cannot be provided by the AAC.

Note: The torque for the PE connection is 2.0 ± 0.5 Nm.



Circuit Status

The area access control light curtain is not obstructed and its safety output contacts (4-5 and 8-9) are open . The outputs of the safety relay are closed, and the motor is ready to run.

Operating Principle

STARTING: Press the Start button to energize contactors K1 and K2. The motor starts with the two normally open contacts of K1 and K2 holding the circuit energized.
STOPPING: Obstructing the light curtain deenergizes the safety outputs of the MSR127, which in turn drops out K1 and K2. The contactors disconnect the motor from its power source, and the motor coasts to a stop. Clearing the obstruction in the light curtain does not cause the motor to energize (the Start button must be pressed). The motor can also be turned off by pressing the stop button.

Fault Detection

Upon successful completion of internal checks on power up, the GuardShield light curtain energizes its outputs with no objects present. The GuardShield light curtain outputs turn on. If a crossfault is detected, the GuardShield light curtain goes to a lockout state with its outputs off. After successful completion of internal checks, the MSR127 checks the signals from the light curtain. If OK, the MSR127 then checks the status of the K1 and K2 contactors. If either K1 or K2 fails in the actuated state, the other contactor will disconnect the motor. The MSR127 will detect the faulted contactor and will not allow the motor to restart until the fault is corrected.

Ratings

This circuit meets the safety performance requirements of Category 4 of EN954-1:1996. This circuit executes a Category 0 stop.

Figure 15: Connection diagram

Arc-suppression

ATTENTION

In case of an inductive load: Use arc-suppression elements!

Suitable arc-suppressors must be connected in parallel with the inductance. Connection in parallel with the output contact is not permitted. Please also note that the selection of the suppressors can increase the total switch off times.

Suppression diodes should not be used as arc-suppressors, as they considerably increase the switch off time. RC elements are more suitable than varistors.

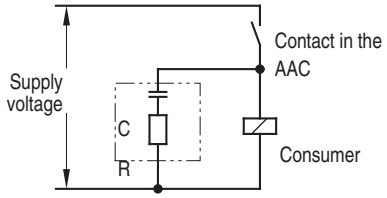


Figure 16: Circuit for an inductive load

Supply voltage	R	C
115…230 V	220 ohms	0.22 µF
24 V	100 ohms	2.2 µF

Table 11: Examples for arc-suppressors

Cross-circuit monitoring

The cables for the relay contacts are not monitored for cross-circuits by the AAC receiver.

ATTENTION

Suitable measures

Take suitable measures for cross-circuit monitoring.

These can be:

- Laying cables from the AAC receiver to the loads protected against cross-circuits,
- Screening output cables separately and connecting screen to 0 V,
- Integration of the two normally open contacts at different voltage levels.

Overcurrent protection (fuse)

A fuse is to be installed in the control circuit with a rating to suit the maximum current on the output relay.

Commissioning

ATTENTION

Commissioning requires a thorough check by qualified safety personnel!

Before you operate a system protected by the AAC devices for the first time, make sure that the system is first checked and released by qualified safety personnel. Please read the notes in “On safety” on page 5.

The device is switched on by applying the supply voltage to the sender and receiver unit. After max. 10 seconds the AAC devices are ready for operation.

Aligning transmitter and receiver

After all parts have been mounted and connected, the related transmitter and receiver must be aligned in relation to each other.

ATTENTION

Secure the system. No dangerous movement possible!

Ensure that the dangerous state of the machine is (and remains) switched off! During the alignment process, the outputs of the AAC devices are not allowed to have any effect on the machine.

Alignment using the diagnostics LEDs

Switch on power supply. The yellow diagnostics LED of the AAC transmitter must light up.

Align devices such that the green diagnostics LED on the AAC receiver illuminates.

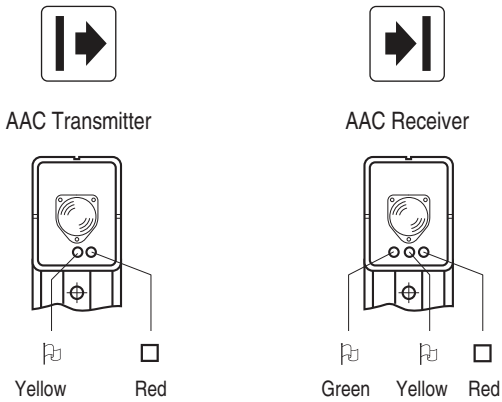


Figure 17: AAC transmitter unit and receiver unit

For optimal alignment the transmitter and receiver, the boundaries are to be determined by pivoting the transmitter unit and receiver unit horizontally and vertically. On leaving the related optical area, the yellow diagnostics LED on the AAC receiver starts to illuminate. Then fasten transmitter and receiver in the middle of the optical area determined.

Alignment using the laser alignment aid

At large scanning ranges or in case of the usage of corner mirrors, the laser alignment aid significantly simplifies alignment. The alignment aid is available as an accessory (see Table 16 on page 21).

- Screw the adapter to the laser alignment aid,
- Mount the laser alignment in front of the transmitter (clamp),
- Switch on laser alignment aid,
- Attach a piece of white cardboard or with cardboard reflective tape to the receiver (beam array is easier to detect),
- Align transmitter such that the laser beam array is incident on the middle of the receiver optics,
- Fasten transmitter in this position,
- Switch off laser alignment aid,
- Remove laser alignment aid,
- Repeat the process starting from the receiver,
- Switch on sensors.

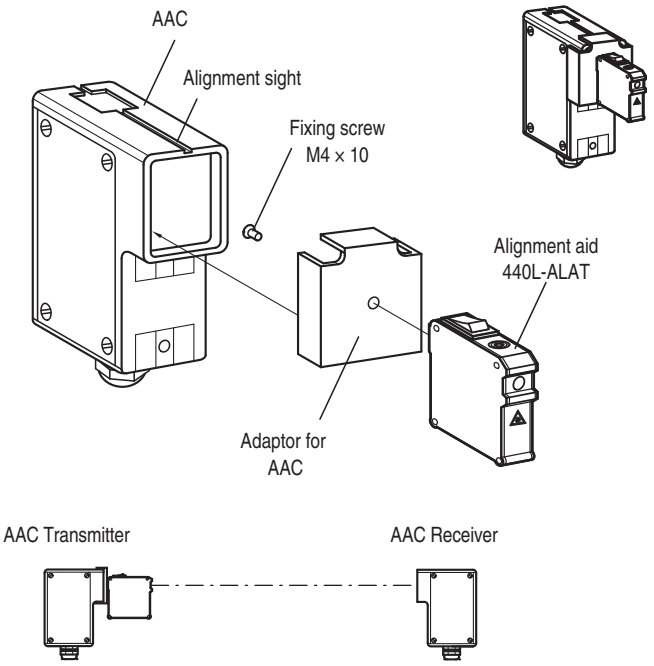


Figure 18: Mounting the laser alignment aid

Test notes

Tests before the initial commissioning

The purpose of the pre-commissioning tests is to confirm the safety requirements specified in the national/international rules and regulations, especially in the Machine and Work Equipment Directive (EU Conformity).

To ensure the correct function, check as described in “Daily functional checks of the protective device” on page 16.

- Number of transmitter and receiver must match, the distance between them must comply with the operating range stated in the technical specifications.
- It must only be possible to access the hazardous area through the light path between transmitter and receiver.
- It must not be possible to climb over, to crawl beneath or to circumnavigate the protective device.
- Additionally, check the effectiveness of the protective device mounted to the machine, using all selectable operating modes as specified in the checklist (see “Checklist for the manufacturer” on page 23). Use this checklist as a reference before commissioning the system for the first time.
- Ensure that the operating personnel of the machine protected by the AAC devices are correctly instructed by qualified safety personnel before being allowed to operate the machine. Instructing the operating personnel is the responsibility of the machine owner.

Daily functional checks of the protective device

The effectiveness of the protective device must be checked daily or prior to the start of work by a specialist or by authorized personnel, using the correct test rod.

Testing the light path between transmitter and receiver:

- Completely cover each light beam with a test rod that is not transparent to light (at least 30 mm diameter) at the following positions:
  - Immediately in front of the sender,
  - In the middle between transmitter and receiver (or between the corner mirrors),
  - Immediately in front of the receiver,
  - On the use of corner mirrors, immediately before and after the deflection.

This must produce the following result:

- The red diagnostics LED must illuminate on the receiver for the related AAC single-beam photoelectric safety switch.

and

- As long as the light beam is interrupted, it must not be possible to initiate the dangerous state.

ATTENTION	Do not operate the machine if during the test the green diagnostics LED on the receiver is lit! If the green diagnostics LED on the receiver lights up during the test even for a short period, work must stop at the machine. In this case the installation of the AAC devices must be checked by qualified safety personnel.

Further tests

- Check the protective device for damage or wear, particularly the mounting, the electrical connection and the connection cable, the housing and the front screen.
- Check whether the access to the hazardous area is only possible by interrupting the light path between transmitter and receiver (e.g. correct mounting of mechanical protective devices).
- Check whether the protective device is effective for the set operating mode.

Regular inspection of the protective device by qualified safety personnel

- Check the system, following the inspection intervals specified in the national rules and regulations. This procedure ensures that any changes on the machine or manipulations of the protective device after the initial commissioning are detected.
- If major changes have been made to the machine or the protective device, or if the AAC single-beam photoelectric safety switch has been modified or repaired, check the equipment again as per the checklist in the annex.

Care and maintenance

The AAC devices are maintenance-free. The integrated relay contacts are subject to normal wear. The front screen of the sensors should be regularly cleaned and also if contaminated.

Note: Avoid scratching the front screens as well as the formation droplets, frost and ice on the front screens, as the optical properties may change.

- Do not use aggressive cleaning agents.
- Do not use abrasive cleaning agents.

Note: Static charges cause dust particles to be attracted to the front screen. You can reduce this effect by using an anti-static plastic cleaner and lens cloth.

How to clean the front screen:

- Use a clean and soft brush to remove dust from the front screen.
- Now wipe the front screen with a clean and damp cloth.

Note: After cleaning, check the position of transmitter and receiver to ensure that the protective device cannot be bypassed (climbing over, crawling beneath or standing behind).

- Verify the effectiveness of the protective device as described in “Test notes” on page 16.

Fault diagnosis

This section describes how to identify and rectify errors and malfunctions during the operation of the AAC devices.

In the event of faults or errors

ATTENTION	Cease operation if the cause of the malfunction has not been clearly identified! Stop the machine if you cannot clearly identify or allocate the error or if you cannot safely rectify the malfunction.

ATTENTION	Complete function test after rectification of fault! After rectifying a fault, perform a complete function test as per “Test notes” on page 16.

Rockwell Automation technical support

If you cannot remedy an error with the help of the information provided in this chapter, please contact your Rockwell Automation technical support staff.

Status displays of the diagnostics LEDs

This section describes the meaning of the diagnostics LED and how to respond.

Diagnostics LEDs of the transmitter

Display		Possible cause	Rectification of the error
Yellow	Red		
○	○	No operating voltage, or voltage too low	➢ Check the supply voltage and activate, if necessary.
●	☼ (1 Hz, power up delay 10%)	System error	➢ Switch the device off for at least 3 seconds and then back on again. If the error continues to occur: ➢ Replace the device.

Table 12: Diagnostics LEDs AAC

Diagnostics LEDs of the receiver

Display			Possible cause	Rectification of the error
Green	Yellow	Red		
○	○	○	No operating voltage, or voltage too low	➢ Check the supply voltage and activate, if necessary.
○	☼ (1 Hz, power up delay 10%)	●	System error	➢ Switch the device off for at least 3 seconds and then back on again. If the error continues to occur: ➢ Replace the device.
○	☼ (1 Hz, power up delay 90%)	●	Error in the supply voltage or unknown sender detected	➢ Switch the device off for at least 3 seconds and then back on again. ➢ Check whether the power supply complies with the specification (see “Important information for the installation” on page 12). ➢ Check whether the power supply complies with the technical specifications (see “Technical specifications” on page 19). ➢ Check the distance from reflective surfaces (see “Minimum distance to reflective surfaces” on page 9 and from other single-beam photoelectric safety switches. If the error continues to occur: ➢ Replace the device.

Table 13: Diagnostics LEDs

Technical specifications

Description	Minimum	Typical	Maximum
General system data			
Operating range AAC Receiver 20 m AAC Receiver 70 m	 0.5 m 15 m		 20 m 70 m
Number of beams	1		
Synchronisation	optical, without separate synchronisation cable		
Detection capability		30 mm	
Protection class (EN 50178:1998) [a]	I		
Enclosure rating (IEC 60529)	IP67		
Operating mode	Protective operation without start and restart interlock		
Supply voltage V_S [b]	19.2V DC	24V DC	28.8V DC
Residual ripple [c]			±10%
Power-up delay of receiver and sender before ready		5 s	10 s
Type	Type 4 (IEC 61496)		
Safety integrity level [d]	SIL3 (IEC 61508), SILCL3 (EN 62061)		
Category	Category 4 (EN ISO 13849-1)		
Performance Level [4]	PL e (EN ISO 13849-1)		
B_{10d} value	AC-15, 230V, 0.4 A: 1 x 10^6 switching operations AC-15, 230V, 2.0 A: 2.6 x 10^5 switching operations DC-13, 24V, 0.6 A: 1 x 10^6 switching operations DC-13, 24V, 1.5 A: 2 x 10^5 switching operations		
PFHd (mean probability of a dangerous failure per hour)	4.0 x 10^{-9}		
T_M (mission time)	20 years (EN ISO 13849)		

a. Safety extra-low voltage SELV/PELV is mandatory.
b. The external voltage supply must be capable of buffering brief mains voltage failures of 20 ms as specified in EN 60204. Suitable power supplies are available as accessories from Rockwell Automation.
c. The maximum supply voltage limits must not be exceeded, minimum levels must be achieved.
d. For detailed information on the exact design of your machine/system, please contact your local Rockwell Automation sales office.

Description	Minimum	Typical	Maximum
Transmitter unit			
Wavelength		950 nm	
Test input Type of circuit: • Duration of the actuation of the normally closed contact • Response time to test input signal	Voltage-free normally closed contact or wire jumpers between the test contacts[a] 50 ms	150 ms	200 ms
Power consumption			6 W
Weight			1 kg
Receiver unit			
Outputs	Voltage-free relay contacts, 2 normally open contacts, 1 normally closed contact (2 normally closed contacts connected in parallel internally)		
Contact material	Ag alloy with Au coating		
Switching frequency			0.2 Hz
Switching voltage	10V DC 10V AC		30V DC 230V AC
Switching current	20 mA		2 A
Mechanical life relay contacts	$\geq 10^7$ switching operations		
Electrical service life of relay contacts with reference loads	$\geq 10^5$ switching operations		
Reference loads by usage category	AC-15 with 230V, 2 A, AC-1 with 230V, 2 A, DC-1 with 24V, 2 A, DC-13 with 24V, 1.5 A		
Response time			22 ms
Switch-off time	80 ms		
Power consumption			8 W
Weight			1 kg

a. Connect the contacts on the AAC only to circuits that comply with the requirements for safety extra-low voltage (SELV/PELV).

Description	Minimum	Typical	Maximum
Operational data			
Connection	Cable gland (PG 13.5)		
Core cross-section	0.2 mm^2		1.5 mm^2
Cable length for cross-section 0.25 mm^2 0.75 mm^2 1.5 mm^2			 14 m 42 m 83 m
Ambient operating temperature	–25 °C		+55 °C
Storage temperature	–25 °C		+70 °C
Air humidity (no dew)	15%		95%
Dimensions	see Dimensional drawings		
Vibration resistance	5 g, 10…55 Hz according to EN 60068-2-6		
Shock resistance	10 g, 16 ms according to EN 60068-2-29		
Environmental data			
Housing	Aluminium alloy ALSI12(CU)		
Front screen	Poly carbonate (scratch-resistant coating)		
Circuit boards	Glass fiber reinforced epoxy resin		
Packaging	Corrugated cardboard		

Table 14: Technical specifications

Ordering information

Devices

Part	Type	Part number
Single-beam photoelectric safety switch: transmitter unit	AAC transmitter	440L-T4F2070Q
Single-beam photoelectric safety switch: Receiver unit, scanning range 0.5 m…20 m	AAC receiver 20 m	440L-R4F0020Q
Single-beam photoelectric safety switch: Receiver unit, scanning range 15 m…70 m	AAC receiver 70 m	440L-R4F1570Q

Table 15: Ordering information

Accessories

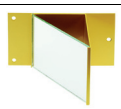
Description		Part number
	Laser alignment tool	440L-ALAT
	Adaptor for alignment aid on AAC	440L-ALBRK1
	Mounting bracket for AAC	440L-AMBRK4
	Corner mirror for scanning range 0…30 m	440L-AMIRR1
	Mounting kit for 440L-AMIRR1	440L-AMKIT (Figure 22)
	Mounting bracket for mirror 440L-AMIRR1	440L-AMBRK1
	Glass corner mirror, 45° angle 0…30 m	440L-AMIRR2

Table 16: Accessories ordering information

Dimensional drawings

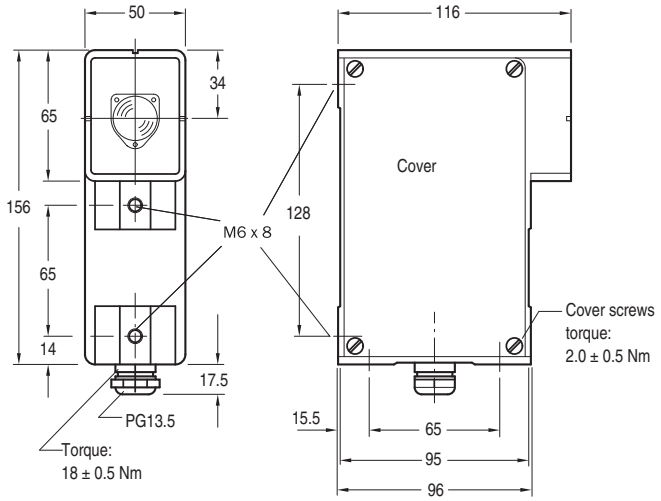


Figure 19: AAC

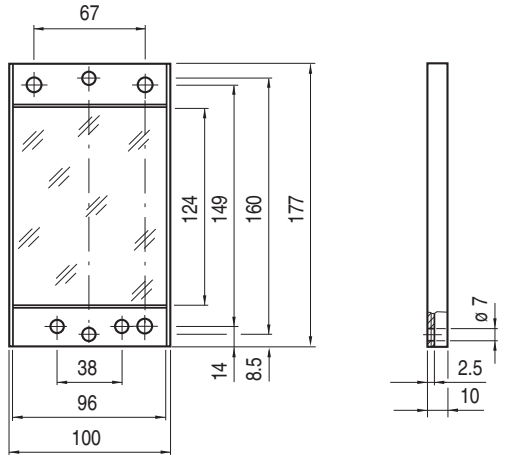


Figure 20: Deflector mirror 440L-AMIRR1

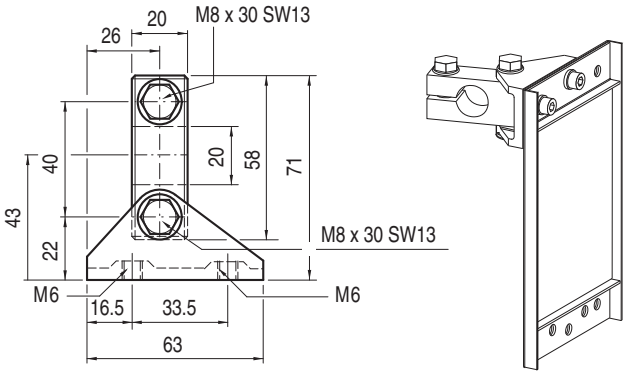


Figure 21: Bracket for corner mirror 1 (440L-AMBRK1)

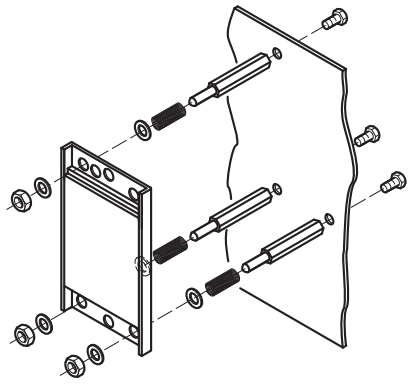


Figure 22: Spring fastening for corner mirror (440L-AMKIT)

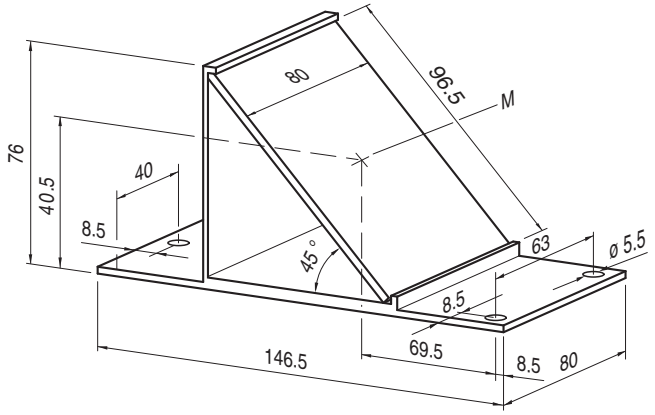


Figure 23: Corner mirror (M = Middle of the mirror surface) (440L-AMIRR2)

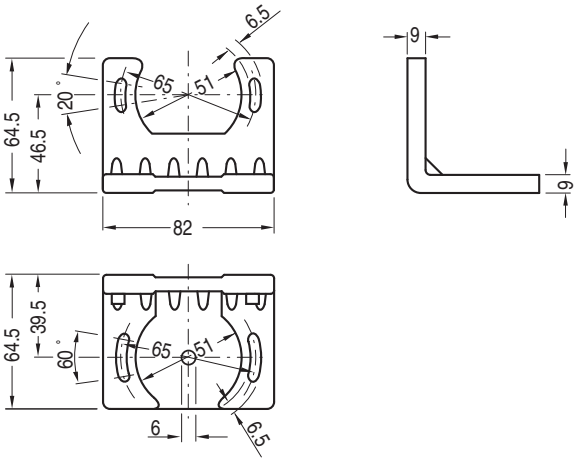


Figure 24: Mounting bracket (440L-AMBRK4)

Checklist for the manufacturer

Checklist for the manufacturer/installer for the installation of electro-sensitive protective equipment (ESPE)			
Details about the points listed below must be present at least during initial commissioning – they are, however, dependent on the respective application, the specifications of which are to be controlled by the manufacturer/installer. **Note**: Rockwell Automation authorizes the reproduction of this checklist for use of the recurring tests. This checklist should be retained and kept with the machine documentation to serve as reference during recurring tests.			
1.	Have the safety rules and regulations been observed in compliance with the directives/standards applicable to the machine?	Yes	No
2.	Are the applied directives and standards listed in the declaration of conformity?	Yes	No
3.	Does the protective device comply with the required control category?	Yes	No
4.	Is the access to the hazardous area/hazardous point only possible through the protective field of the ESPE?	Yes	No
5.	Have appropriate measures been taken to prevent (mechanical protection) or monitor unprotected presence in the hazardous area when protecting a hazardous area/hazardous point and have these been secured against removal?	Yes	No
6.	Are additional mechanical protective measures fitted and secured against manipulation which prevent reaching under, over or around the ESPE?	Yes	No
7.	Has the maximum stopping and/or stopping/run-down time of the machine been measured, specified and documented (at the machine and/or in the machine documentation)?	Yes	No
8.	Has the ESPE been mounted such that the required safety distance from the nearest hazardous point has been achieved?	Yes	No
9.	Are the ESPE devices correctly mounted and secured against manipulation after adjustment?	Yes	No
10.	Are the required protective measures against electric shock in effect (protection class)?	Yes	No
11.	Is the control switch for resetting the protective device (ESPE) or restarting the machine present and correctly installed?	Yes	No
12.	Are the ESPE outputs (OSSDs) integrated in accordance with the stipulated control category, and do they comply with the circuit diagrams?	Yes	No
13.	Has the protective function been checked in compliance with the test notes of this documentation?	Yes	No
14.	Are the given protective functions effective at every setting of the operating mode selector switch?	Yes	No
15.	Are the switching elements activated by the ESPE, e.g. contactors, valves, monitored?	Yes	No
16.	Is the ESPE effective over the entire period of the dangerous state?	Yes	No
17.	Once initiated, will a dangerous state be stopped when switching the ESPE on or off and when changing the operating mode, or when switching to another protective device?	Yes	No
18.	Has the information label for the daily check been attached so that it is easily visible for the operator?	Yes	No
This checklist does not replace the initial commissioning, nor the regular inspection by qualified safety personnel.			

EC declaration of conformity

Rockwell Automation

EC Declaration of Conformity

The undersigned, representing the manufacturer	*and the authorised representative established within the Community*
Rockwell Automation, Inc. ***2 Executive Drive*** ***Chelmsford, MA 01824*** ***USA***	***Rockwell Automation BV*** ***Rivium 1e Straat, 23*** ***2909 LE Capelle aan den IJssel*** ***Netherlands***
Herewith declare that the Products:	***Single Beam Safety Sensor***
Product identification (brand and catalogue number/part number):	***Allen-Bradley / Guardmaster 440L-R4F and 440L-T4F Series*** *(reference the attached list of catalogue numbers)*
Product Safety Function:	***The 440L-R4F and 440L-T4F Series single beam safety sensors are Type 4 active optoelectronic protection devices (AOPD's) consisting of a light sender and light receiver to provide access protection from hazardous areas. They are suitable for applications up to Cat. 4 / Pl e (EN ISO 13849-1), SIL CL3 (EN 62061) and SIL3 (EN 61508).***

are in conformity with the essential requirements of the following EC Directive(s) when installed in accordance with the installation instructions contained in the product documentation:

2004/108/EC	*EMC Directive*
2006/42/EC	*Machinery Directive*

and that the standards and/or technical specifications referenced below have been applied:

EN 61000-6-2:2005	*Electromagnetic Compatibility (EMC) – Part 6-2: Generic standards – Immunity for Industrial Environments*
EN 61000-6-4:2007	*Electromagnetic Compatibility (EMC) – Part 6-4: Generic standards – Emissions standard for industrial environments*
EN 61496-1:2004 + A1:2008	*Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests*
CLC/TS 61496-2:2006 *IEC 61496-2:2006*	*Safety of machinery – Electro-sensitive protective equipment – Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*
EN 60204-1:2006 + A1:2009	*Safety of machinery – Electrical equipment of machines – General requirements*
EN 61508:2001	*Functional safety of electrical/electronic/programmable electronic safety-related systems*
EN 62061:2005	*Safety of machinery – Functional safety of safety-related electrical, electronic and programmable control systems*
EN ISO 13849-1:2008 / AC:2009	*Safety of machinery – Safety related parts of control systems – Part 1: General principles for design*

Conformance of a type sample belonging to the above mentioned product family with the regulations from the EC Machinery Directive has been certified by:

TÜV Rheinland Industrie Service GmbH *Automation, Software and Information Technology (ASI)* *51105 Köln, Germany*	*EC Type Examination Certificate No.* *01/205/5022/10*

Manufacturer:	*Authorised Representative in the Community:*
Daniel L. Nachtigall	
Signature	***Signature***
Name: Daniel L. Nachtigall	*Name:* Viktor Schiffer
Position: Supv – Product Certification Engineering	*Position:* Engineering Manager
Date: 04-Aug-2010	*Date:* 09-Aug-2010

Document Control Number: SEN-0401-A-EN 1 / 2

Allen-Bradley Guardmaster

Rockwell Automation

Catalogue number	*Series* [1]	*Description*
440L-R4F0020-Q		*Single beam safety sensor – low range receiver*
440L-R4F1570-Q		*Single beam safety sensor – high range receiver*
440L-T4F2070-Q		*Single beam safety sensor – emitter*

1) If no series number is given, then all series are covered

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10000104186 Ver 00
August 2010

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